



Suit Engineering & Modeling

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Background



- ▶ Engineering Goal: Enable crew to perform EVA required tasks with the least amount of energy expenditure
 - ▶ If no specific tasks are identified, maximize mobility with a goal of achieving unsuited performance
- ▶ Mobility is a combination of:
 - ▶ Range of motion
 - ▶ Work or joint torque throughout that range of motion
 - ▶ Natural movement (programming)
- ▶ Mobility is also heavily impacted by fit
 - ▶ Fit is usually evaluated by how well the suit's mobility joints line up with the crew's joints throughout the required tasks



Testing Limitations



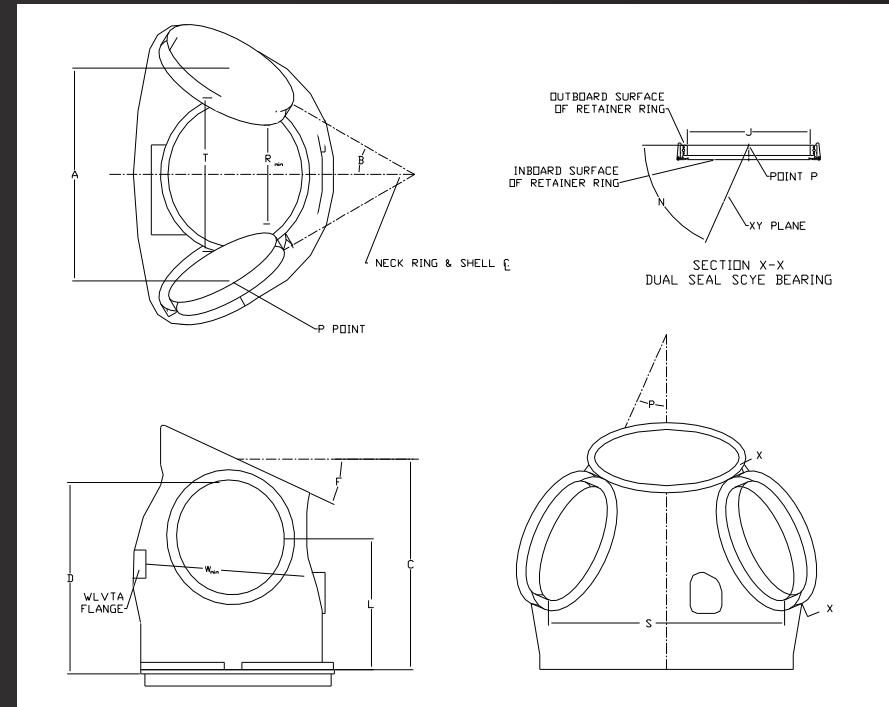
- ▶ Development budgets usually do not allow multiple sizes of suits
 - ▶ Consistent subject fit and performance can be a challenge when evaluating suit architectures
 - ▶ Iterations of joint design are expensive and slow
 - ▶ Poor concept or just poor implementation
- ▶ Modeling suit fit and mobility offers a way of evaluating fit, range of motion, and natural movement of mobility architectures without building a fleet of suits
 - ▶ Models need to be validated, but can help guide development
- ▶ Examples of modeling efforts
 - ▶ Fit for Z-2 development



Past Sizing Method



- ▶ Historical Sizing method (Mark III & EMU)
 - ▶ Identify population to fit
 - ▶ Identify locations on the suit that correspond to the critical anthropometric dimensions
 - ▶ Validate measurements by building a mockup structure and fit checking crew population
 - ▶ Results:
 - ▶ 2D measurements offer little guidance on sizing of population
 - ▶ Fit checking crew population ensures current astronauts will fit, but is not very predictive of future sizes

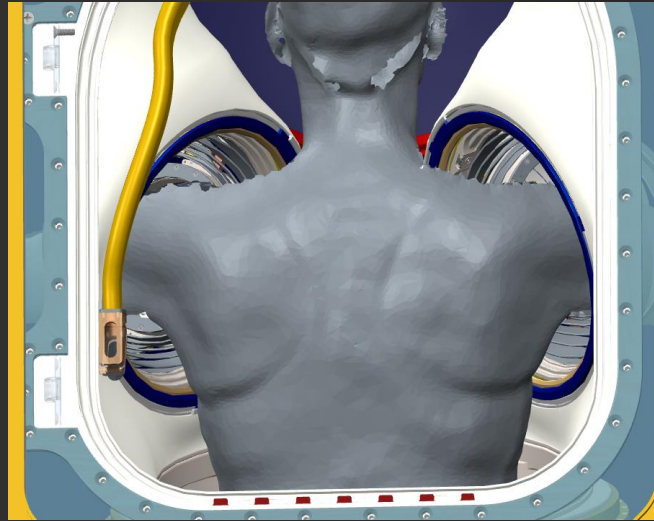


Recent Modeling Based Sizing



► Z-2 Sizing Method

- Identify population to fit
- Obtain boundary manikins/scans to represent population
- Conduct fit checks of manikins from entire population set in various positions
- 3D print HUT structure and validate model results with subject fit checks
- Results:
 - Offers better evaluation of 3D body shapes
 - Once validated, can easily fit check entire population size ranges
 - By evaluating multiple arm positions, we can evaluate good joint placement and sizes



Future Needs



- ▶ Fit – Custom or Fleet Sizing

- ▶ Modeling analysis to produce a predicted optimal fit for custom sizing
- ▶ Modeling analysis to produce the best sizing across a fleet of suits and the number of suits
 - ▶ Combined with mobility analysis to predict mobility when not in optimal fit

- ▶ Mobility

- ▶ Analysis of current mobility architecture to understand what aspects of the mobility architecture or joints could be improved to offer most natural movement or most efficient interaction with crew
 - ▶ Joint angle and position
 - ▶ Joint sizing and subject indexing
 - ▶ Bearing torque

